# AEROSPACE VEHICLE

## BACKGROUND

Manned spacecraft employed to date have been characterized by very limited hypersonic maneuverability with a lift-over-drag ratio (L/D) of only about 0.3. In addition, the vehicles have had virtually no subsonic lift and have been lowered by parachutes into the ocean. This combination of design characteristics, although quite suitable for early space exploration purposes, is not very attractive for more routine space operations. It is desirable to have a ferry logistics vehicle for shuttling men, equipment, and expendable materials such as fuel to an orbiting space station such as a manned orbital laboratory. It is also desirable to have a vehicle for orbital maneuvering to approach a satellite and for containing the satellite for recovery.

For maximum reusability it is desirable to have a vehicle that is land landable under airplanelike control conditions with flying qualities at least as good as the X-15 aircraft, manufactured by North American Aviation, Inc. Thus, it is desirable to have a vehicle having a hypersonic L/D of at least one and a subsonic L/D of at least three. Such a vehicle should be adaptable to carrying a varying number of crew members or carrying a substantial cargo. In addition, such a vehicle may be adaptable to other space missions such as, for example, satellite recovery and return.

Lifting reentry vehicles designed to date are characterized by good lift and control features, however, the vehicles are generally fairly long and flat with relatively poor volumetric efficiency so that a relatively small cargo volume is available within the vehicle. In addition, lifting bodies designed to date are very asymmetrical from top to bottom or in profile view, and require special adaptations to rocket boosters in order to have acceptable characteristics during the launch phases of a mission. When mounted on a cylindrical rocket booster the asymmetrical lifting bodies must be canted or offset or both to properly locate the center of gravity and the center of lift to prevent the launch vehicle from veering to one side. A vehicle as provided in practice of this invention is fitted symmetrically on conventional boosters without problems.

The reentry vehicle for the Apollo Lunar Landing program, manufactured by North American Rockwell Corporation, comprises a command module in the general shape of a cone which accommodates three crew members facing toward the apex of the cone. During space flight the command module is mated to a cylindrical service module which contains fuel, life support systems and a restartable rocket engine for space maneuvering. At the end of a space flight the entire service module is jettisoned and the command module is oriented so as to enter the earth's atmosphere with the blunt aft end forward, that is, with the crew facing rearwardly along the line of flight. An ablative heat shield on the aft end of the command module helps dissipate the energy of reentry and afford thermal protection for the crew. After the command module is slowed by aerodynamic friction, parachutes are deployed and the module is lowered into the ocean.

## BRIEF SUMMARY OF THE INVENTION

In the practice of this invention, according to a preferred embodiment there is provided an aerospace vehicle with a high degree of symmetry comprising a body having substantial bilateral aerodynamic symmetry about two orthogonal planes extending longitudinally thereof and a pair of aerodynamic fairings located along the midline thereof on one of the planes of symmetry for providing lift at hypersonic velocities. Further, in one embodiment there may be provided selectively pivotable wings extendable from the fairings for providing additional lift at subsonic velocities. In one embodiment a blunt aft end on the vehicle provides a low velocity region in an aerodynamic wake behind the body for affording thermal protection for elements of the vehicle in the low velocity region. A rocket engine with a jettisonable expansion bell provides thrust optimized for both space and the atmosphere with the same engine.



Objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 illustrates in perspective an aerospace vehicle as employed in space;

FIG. 2 illustrates in perspective the vehicle of FIG. 1 with wings and landing gear extended for landing;

FIG. 3 illustrates in perspective cutaway some of the internal structure of the vehicle of FIG. 1;

FIG. 4 comprises a side section of the vehicle of FIG. 1 further illustrating additional details of the interior;

FIG. 5 comprises a transverse section of the vehicle of FIG. 4;

FIG. 6 further illustrates the extendable wing arrangement on the vehicle of FIG. 1;

FIG. 7 comprises an aft view of the vehicle of FIG. 1 illustrating certain movable elements;

FIG. 8 further illustrates in perspective the landing gear of the vehicle of FIG. 1; and

FIG. 9 illustrates a booster for the aerospace vehicle.

Throughout the drawings like reference numerals refer to like parts.

An aerospace vehicle as provided in the practice of this invention according to a preferred embodiment employs modifications of many of the basic elements developed in the course of the Apollo Lunar Landing Program for maximum utilization of the national investment in this program. Thus, as illustrated in FIG. 1 there is provided a substantially conical command module **10** mated to a substantially cylindrical service module **11**. The cone and cylinder are blended together for aerodynamic smoothness and the apex of the cone is somewhat rounded for optimum distribution of heat load thereon during reentry. A pair of aerodynamic fairings **12** are symmetrically located on opposite sides of the service module **11** substantially along the midline thereof so that the vehicle has substantial bilateral symmetry from top to bottom as well as from side to side. It is preferred that the leading edge of the fairings **12** be essentially a continuation of the conical line of the command module **10**. If desired the fairings **12** may extend a short distance forward on the conical command module and diverge somewhat more rapidly than the cone. The aerodynamic fairings **12** provide lift for the aerospace vehicle at hypersonic velocities when the angle of attack of the vehicle is in the range of from about 10° to 30°. A pair of fins **13** are provided on the outboard edge of the fairings **12** toward the aft end thereof for providing lateral stability. The fins **13** diverge slightly from each other, each being about 10° off vertical. Rudders **14** form a portion of the trailing edge of the substantially vertical fins **13** for providing yaw control in the atmosphere.

Bilateral symmetry in plan view is, of course, quite conventional in aircraft relying on aerodynamic lift from the atmosphere. Heretofore aircraft have been asymmetrical in profile view in order to obtain lift from aerodynamic shaping without assuming unduly high angles of attack. Similarly aerospace reentry vehicles have either been symmetrical for ballistic travel with insignificant lift or have been asymmetrical in profile to obtain a compromise between hypersonic and subsonic lift. Conventional launch boosters for reentry vehicles are symmetrical cylinders with no significant side loads during launch of symmetrical vehicles. Placing an asymmetrical reentry vehicle on a conventional booster leads to side loads on the booster during some phases of launch thereby applying heavy bending loads on the long boosters and requiring steering during launch to prevent the entire vehicle from deviating from a desired flight path.

A vehicle as provided in practice of this invention is substantially symmetrical in profile view except for nearly vertical fins **13** which have no substantial effect on aerodynamic lift.